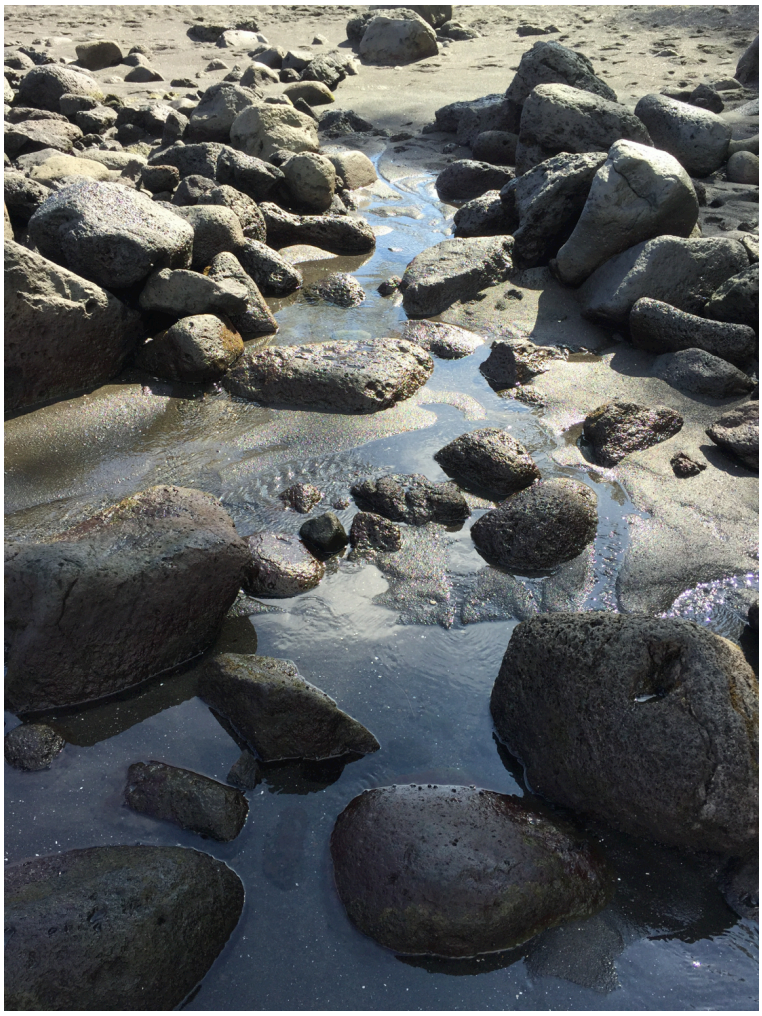
Understanding the Pūnāwai of Keaukaha, HI



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ABSTRACT

Global climate change is altering the natural state of the earth. Ecosystems around the world are being affected with a large concern being the availability of freshwater. As a result of climate change Hawai‘i is predicted to experience a significant decrease in precipitation. And although Hawai‘i is not currently experiencing unavailability of freshwater resources the focus of this study is to begin to understand one of the most abundant freshwater resources in Hawai‘i, freshwater springs. Three approaches were used to begin understanding the freshwater springs in Keaukaha, HI; reading through literature, conducting field surveys as well as conducting informal interviews. Through the field surveys it was found that shoreline springs are easier to sample at lower low tides during new and full moons. It was also found that the shoreline springs move with the tides. Through the informal interviews it was found that to study and protect the freshwater springs in Keaukaha, HI we must also study and protect Lake Waiau on Mauna Kea. It was also found that in order to study pūnāwai we must observe them through a Hawaiian perspective. This study provides a starting point in understanding the pūnāwai of Keaukaha, HI through both a scientific and cultural lens, however more information is necessary to provide comprehensive and conclusive results.

INTRODUCTION

Global climate change is altering the natural state of the earth (Chapin et al. 2000). Ecosystems around the world are being affected with a great concern being the availability of fresh water. Across the globe it is predicted that climate change will result in wet areas becoming wetter and dry areas becoming drier (Milly et al. 2005). In Hawai‘i, however, the wet-season (November to April) is predicted to experience a significant decrease in precipitation (Timm et al. 2014). Although Hawai‘i is not currently experiencing a decline in freshwater availability a better understanding of Hawai‘i’s freshwater resources needs to be established.

Hawai‘i located in the North Pacific receives 375-450 inches of rain per year. Due to the mountains, peaks, valleys and slopes, Hawai‘i is home to a very unique climate. Mauna Kea and Mauna Loa located on Hawai‘i Island (elevation 4,205 m and 4,169 m respectively) creates a type of rain called orographic rain. Trade winds carried over the ocean come into contact with these mountains and the moist air from the ocean rises, condenses and falls as precipitation (NOAA website). This effect naturally provides large amounts of rain, which in turn provides large amounts of freshwater.

An impact of climate change on Hawai‘i’s freshwater resources includes a significant decrease in precipitation. The orographic rain naturally produced by Hawai‘i Island’s mountains could be among the most important resulting factors. The natural threshold at which orographic rain occurs could be altered eventually leading to less rainfall, therefore less freshwater. In order to protect the freshwater on Hawai‘i Island we must first understand the natural resources of freshwater. The aim of this study is to begin to understand one of the most abundant freshwater resources in Hawai‘i, pūnāwai or freshwater springs.

To understand pūnāwai it is important to understand its connectivity to groundwater. Pūnāwai are points at which groundwater escapes through cracks or permeable layers of substrate at the surface of the earth (see Fig 1). Springs can occur potentially anywhere near groundwater aquifers dependent upon the substrate that surrounds it. Hawai‘i Island, more particularly Keaukaha located on the east side, is known for its freshwater springs. Therefore the focus of this study is to begin to understand the coatal freshwater springs in Keaukaha, HI.

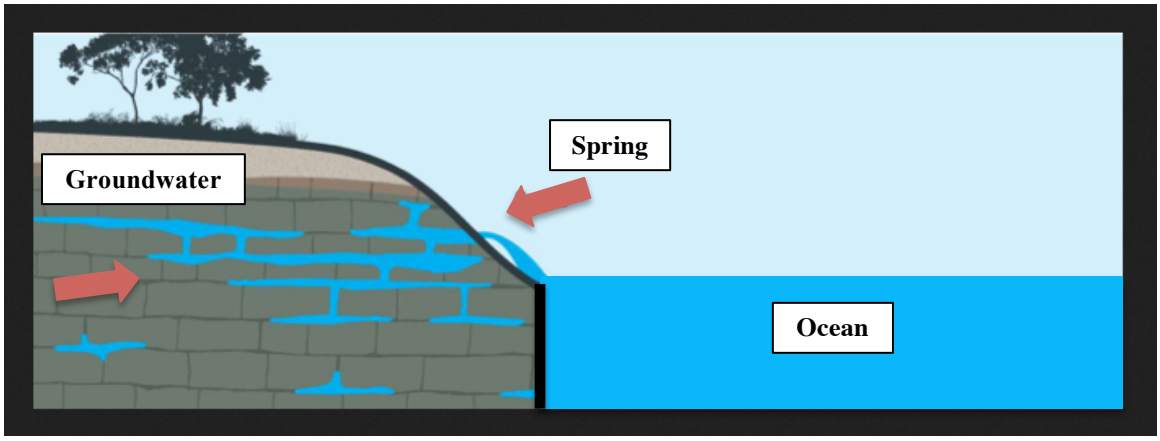

Fig 1. A simplified image depicting the flow of groundwater through permeable substrate and its escape as a coastal freshwater spring.

RESEARCH QUESTIONS

1. Where are the locations of pūnāwai at Waiuli?
2. What is the cultural significance of pūnāwai along the Keaukaha coast?

METHODS

Study Site

Keaukaha is located on the northeastern tip of Hawai‘i Island. This region is known for its freshwater outputs (see Fig 2). Waiuli or Richardsons Beach Park is located on the far east side of Keaukaha, HI (see Fig 3).

Fig 2. Aerial image of the Keaukaha, HI coastline.

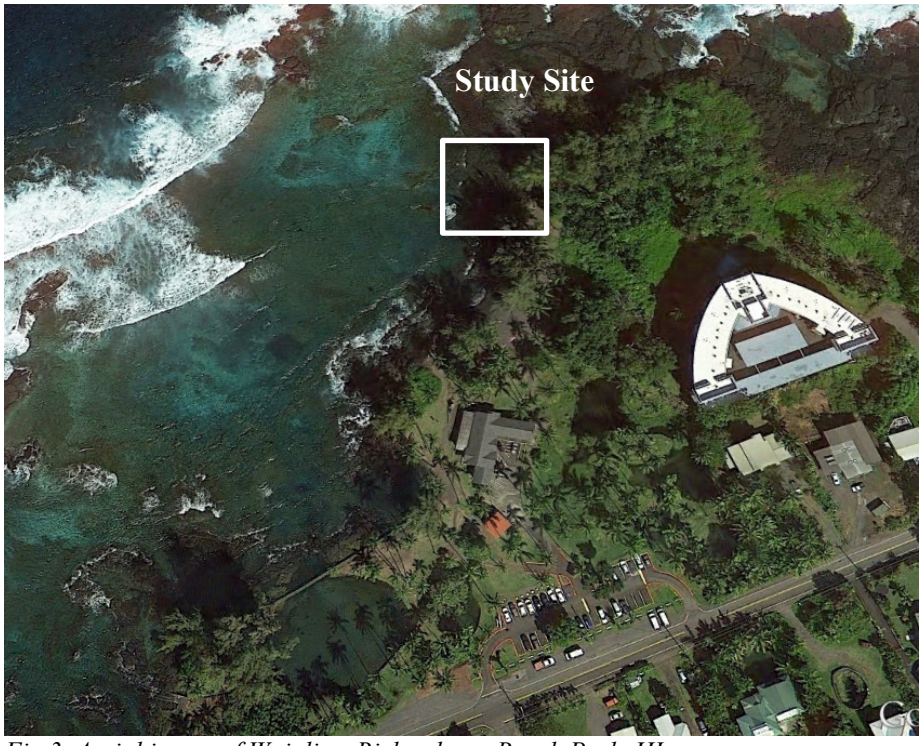

Fig 3. Aerial image of Waiuli or Richardsons Beach Park, HI

Approach

To obtain a comprehensive understanding of pūnāwai in Keaukaha, HI three different appraoches were used; reading through literature, conducting field surveys as well as conducting informal interviews.

Field Methods

A 20 m transect was placed across the face of the beach running parallel to the shoreline. Each end of the transect line was marked with chalk to determine endpoints of transect while surveying various tidal heights. Surveying times were dependent upon the lower low and higher high tides on new and full moons. Water quality parameters (salinity and temperature) were measured using a YSI Pro 2030 and GPS points were taken using a Garmin Oregon 450 to track pūnāwai locations. Measurements were taken at low, mid and high tides.

Visual Surveys

All coastal springs that were visually observed within the 20 m transect were sampled for salinity and temperature. Springs were marked using a GPS. All springs with a value ≥15 ppt were classified as a freshwater spring. Visual surveys were conducted between June 29 - July 1, 2015 at each lower low (-0.5 to 0.65 ft), middle (0.66 to 1.85 ft) and higher high (>1.85 ft) tide. Visual surveys were conducted every hour between 0830 - 1630 on July 2, 2015 regardless of tidal height to obtain an overview of the springs movement from a lower low to a higher high tide. Visual surveys were also conducted on July 3 (at -0.5 ft), 20 (at 1.0 and 0.5 ft) and 21 (at 1.0 ft) (see table 1).

Date	Moon	Tides	Tidal Height (ft)
June 29, 2015	Hua	Lower Low Middle Higher High	-0.4 0.8 2.6
June 30, 2015	Akua	Lower Low Middle Higher High	-0.5 1.12 2.8
July 1, 2015	Hoku	Lower Low Middle Higher High	-0.5 -0.18 2.9
July 2, 2015	Māhealani	Sampled from Lower Low to Higher High (every hour)	Ranged from -0.5 to 3.0
July 3, 2015	Kulu	Lower Low	-0.5
July 20, 2015	Kūlua	Middle	0.5 and 1.0
July 21, 2015	Kūkolu	Middle	1.0

Table 1. Dates, moons and tides sampled.

Shoreline Surveys

A shoreline survey of the 20 m transect was conducted where salinity, temperature and GPS points were collected at every three steps along the shoreline. These surveys were conducted at the same time as the target surveys, however were not conducted on July 20 and 21, 2015.

Waterline Surveys

A waterline survey was conducted to monitor the movement of seawater along the face of the beach. The distance between the transect line and waterline was measured at every meter along the 20 m transect. These surveys were conducted at the same time as the target surveys, however not conducted on July 3, 20 and 21, 2015.

Informal Interviews

Informal interviews were conducted with various community members who have developed an intimate relationship to Keaukaha through years of residency. The members were chosen based on their knowledge of pūnāwai in Keaukaha as well as their connection to Hawaiian beliefs and practices. All interviews were conducted in-person and recorded when applicable.

The interview process provided minimal structure, which allowed the interviewees to share what they felt was necessary based on the topic of our study. Each interview was transcribed and categorized based on highlighted topics that were addressed. This approach provided a comprehensive view of pūnāwai through a Hawaiian perspective.

Data Analysis

Data was averaged in excel then uploaded into ArcGIS to create visual representations of our findings.

RESULTS

Through the field surveys we were able to begin to understand the location of pūnāwai at Waiuli. Through the visual surveys it was found that springs are easier to sample at lower low tides during new and full moons. More springs are present as lower tides. As the tidal height increased less springs were found perhaps becoming inundated by the incoming tides (see Fig 4 & 5). To obtain a detailed visual representation of the springs from a lower low to a higher high tide sampling was conducted approximately every hour on the Māhealani moon phase (see Fig 6). A spatial distribution of the springs at low and middle tides was created confirming spring inundation at higher tides (see Fig. 7). A total of 98 springs were visually observed throughout sampling, however some could have been counted twice due to spring movement with the tides.

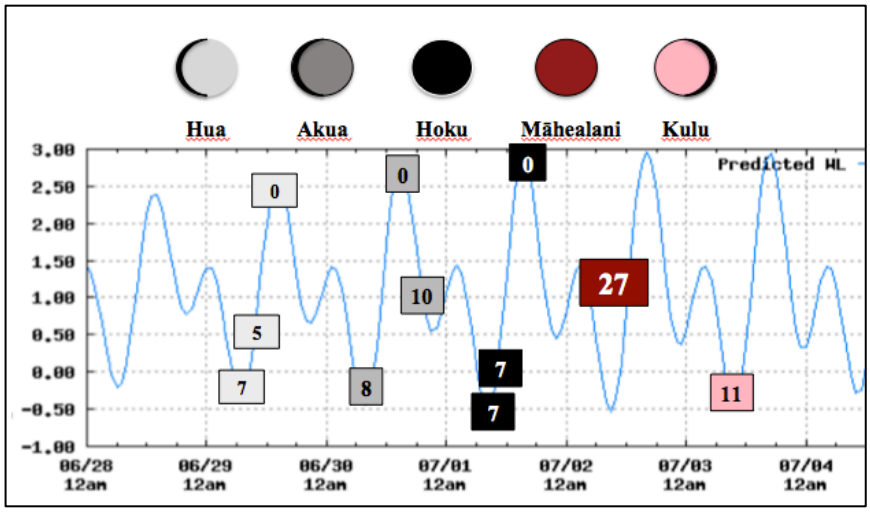

Fig 4. Movement of tidal heights (ft) through June 29 – July 3, 2015. The numbers within the boxes indicate the number of springs found at the sampled tidal heights and the colors are correlated to the different moon phases.

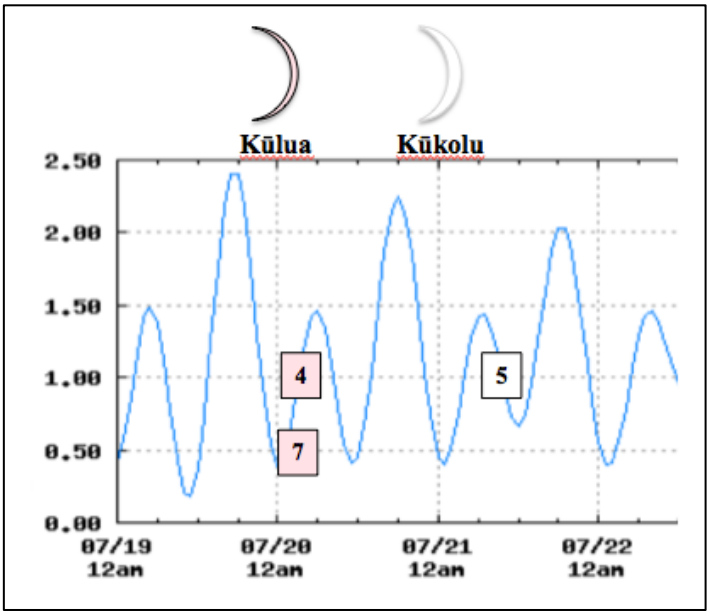

Fig 5. Movement of tidal heights (ft) on July 20 - 21, 2015. The numbers within the boxes indicate the number of springs found at the sampled tidal heights and the colors are correlated to the different moon phases.

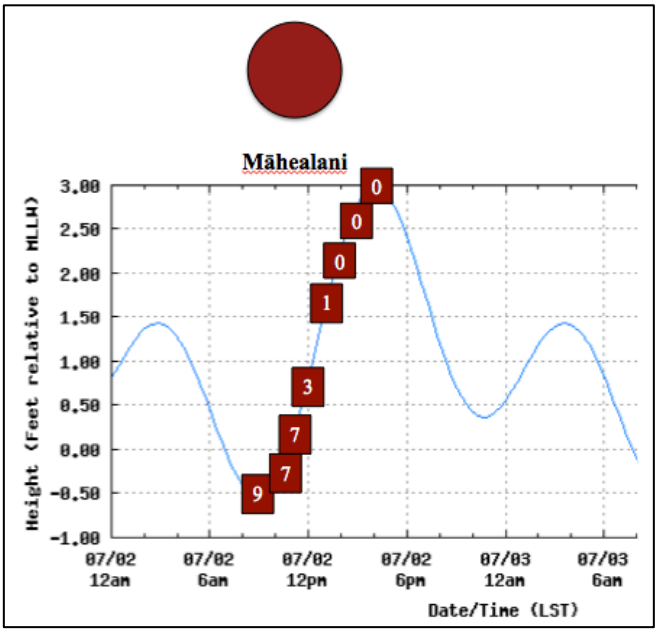

Fig 6. Movement of tidal heights (ft) on July 2, 2015. The numbers within the boxes indicate the number of springs found at each tidal height sampled and the colors are correlated to the Māhealani moon phase.

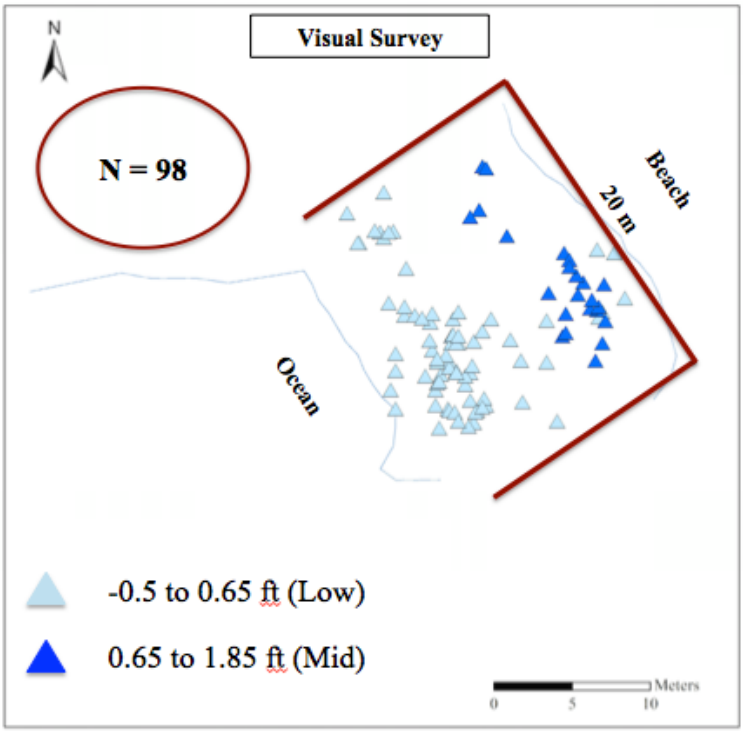

Fig 7. Spatial distribution of visual springs found at low and middle tides throughout all days sampled. The top blue line is the averaged high tide data collected from the waterline surveys. And the bottom blue line is the averaged low tide data collected from the waterline surveys. A total of 98 visual springs were found.

Through the shoreline surveys we observed the freshest water at the lower low tides. As the tidal height increased more salt water was present (see Fig 8, 9 & 10).

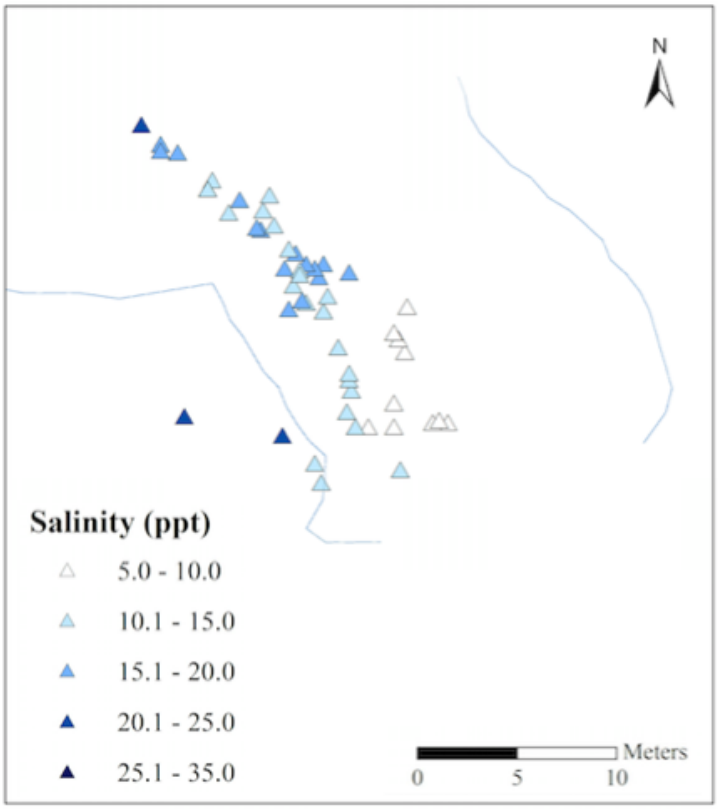

Fig 8. Shoreline survey data at lower low tides on all days sampled.

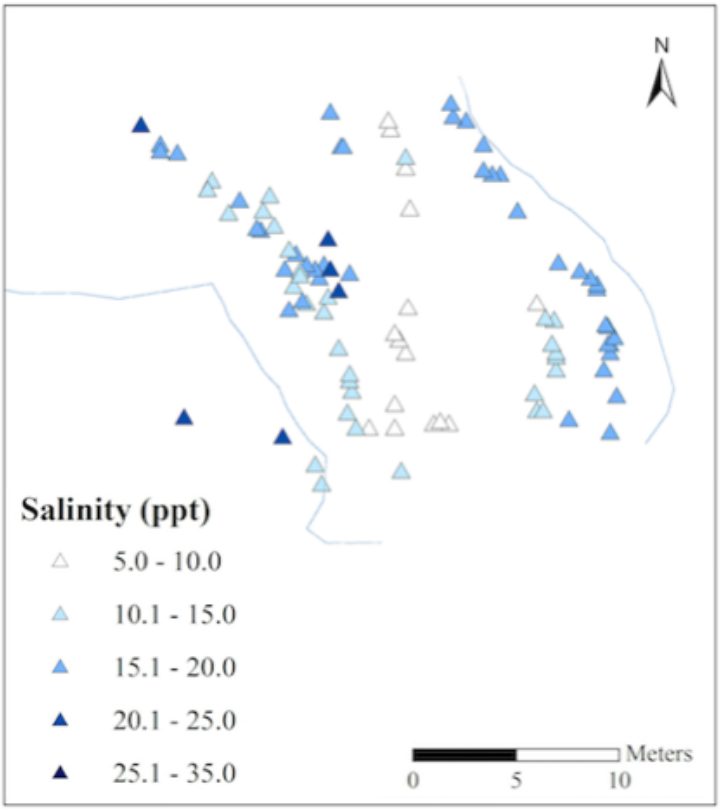

Fig 9. Shoreline survey data at middle tides on all days sampled.

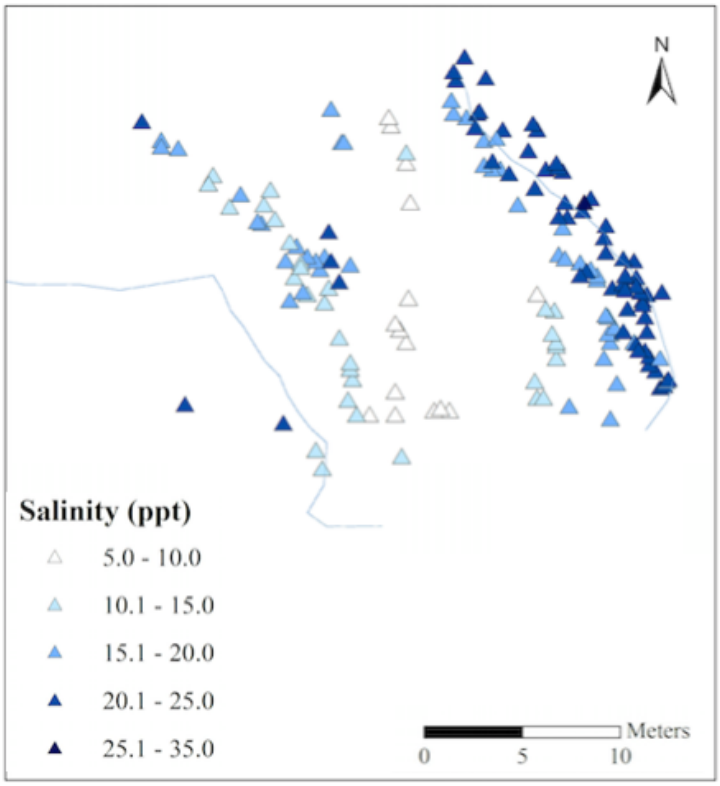

Fig 10. Shoreline survey data at higher high tides on all days sampled.

Through the conducted interviews two key topics were continuously highlighted: Hawaiian perspective and Mauna Kea.

The significance of pūnāwai through a Hawaiian perspective is that no one aspect of life can stand-alone and everything is connected. One cannot look at the pūnāwai in the context of this study, along the Keaukaha coast, without also looking at pūnāwai in the entire concept of life. Through the interviews the term puna was translated as a receptacle of water. The term wai was translated as freshwater. These terms combined, pūnāwai, translates into any receptacle of freshwater. This included clouds, ponds, groundwater, plants, springs and even blood. In Hawaiian perspective freshwater is Kāne, one of the four main gods in Hawaiian culture. These gods are elements of the natural environment. Kāne is the god of procreation. He is the sun. He is the taro. He is among many bodily forms, but is primarily fresh water. A chant that was emphasized through the interviews was "Wai o Kāne" which translates as the water of Kāne. This chant indirectly discusses the hydrological cycle from rainfall at the mountain to discharge as springs at the ocean. In Hawaiian perspective freshwater sustains life and encompasses all life, therefore to study pūnāwai we must also study all life that needs water to survive.

The significance of pūnāwai in Keaukaha is the connection to Mauna Kea with emphasis on Lake Waiau. Lake Waiau sits atop Mauna Kea at an elevation of 3,960 m above mean sea level (Gregory et al. 2005). Lake Waiau is fed directly from precipitation and surface/subsurface runoff. The lake discharges from spillover, evaporation and percolation. The latter leading eventually to freshwater springs. As stated in an interview, "Lake Waiau feeds Keaukaha" through the freshwater springs. It was also said that in

order to study and protect the pūnāwai of Keaukaha we must also study and protect Lake Waiau on Mauna Kea. Although several studies indicate that the freshwater in Keaukaha comes from the peaks of Mauna Loa in Hawaiian perspective the freshwater comes from Mauna Kea. As stated in an interview, "the water comes from Mauna Kea its just Mauna Loa stepped on Mauna Kea's foot."

DISCUSSION

In studying the pūnāwai in Keaukaha we must utilize multiple knowledge systems, western science and Hawaiian cultural perspectives. The field surveys provided information on pūnāwai movement and location. And the informal interviews provided local knowledge and information in observing the pūnāwai through a cultural lens. Combining these knowledge systems provides a more comprehensive understanding of Keaukaha springs.

At the start of this study my scope in studying springs was very narrow, however now I realize that studying springs encompasses much more. All of life is connected from the phases of liquid, solid and gas to the movement from mauka to makai.

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